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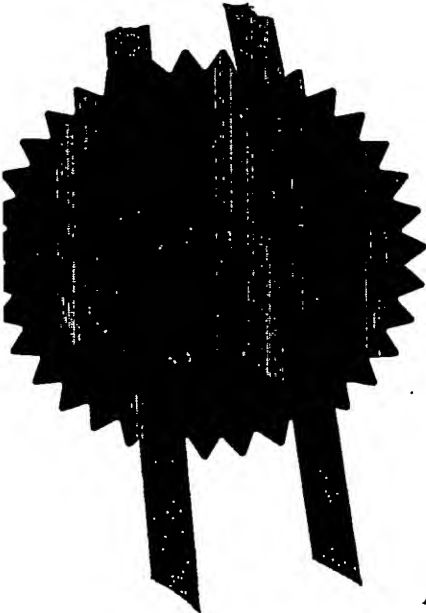
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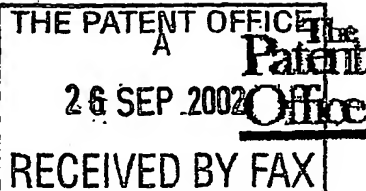
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2.	Patent application number (The Patent Office will fill in this part)	0222256.0		
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	Patents ADP number (if you know it)	8220402001		
	If the applicant is a corporate body, give the country/state of its incorporation	Scotland		
4.	Title of the invention	Signal Transmitting Cable		
5.	Name of your agent (if you have one)	URQUHART-DYKES & LORD ST NICHOLAS CHAMBERS AMEN CORNER NEWCASTLE UPON TYNE NE1 1PE		
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		United Kingdom	0218624.5	10/08/2002
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Signal Transmitting Cable

The present invention relates to signal transmitting cables, and relates particularly, but not exclusively, to optical fibre signal transmitting cables.

Optical fibre cables have traditionally been installed into underground ducts by attaching a pulling member to one end of the cable, and winching the cable into the duct. As a result, such cables were large and heavily reinforced to protect the relatively delicate optical fibre elements from damage during installation.

Traditional cables were constructed by first manufacturing sub-assemblies comprising tubes manufactured from thermoplastic materials and containing between 1 and 12 fibre optic elements. A number of these tubes are then assembled together by stranding them around a central strength member. The stranding process, and the fact that the tube is large relative to the space occupied by the fibre optic elements, means that all fibres experience the same strain when the cable is bent during installation, and the loose tube construction allows the fibres to move and accommodate the strain, resulting in minimal signal losses. A typical such tube sub-assembly is shown in Figure 1, and a cross-section of a traditional cable incorporating such sub-assemblies is shown in Figure 2.

More recent techniques for cable installation involve blowing the cable into a duct by means of compressed air. This distributes the installation force along the entire length of the cable, as a result of which the installation force at the leading end of the cable can be reduced, and much of the

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reinforcement can be removed from the cable. This has provided significant advantages, since there is an increasing requirement for cables to become more compact, primarily because city networks are congested and providing new underground ducts in cities is expensive and involves substantial disruption.

One example of a more compact cable construction for installation by fluid drag produced by compressed air is known as central loose tube construction. This known construction involves installing a large number of optical fibres, typically 24 or 48, in a single tube. The fibres are either randomly arranged inside the loose tube, or are arranged in bundles of 12 fibres, each bundle being loosely wrapped with a very fine textile thread, the bundles then being installed inside the loose tube. The cable construction is then completed by assembling some tensile reinforcement such as aramid yarns around the outside of the tube, and then covering the entire assembly with a thermoplastic outer layer. A cross-section of such an assembly is shown in Figure 4.

An alternative known arrangement to the construction shown in Figure 4 contains a total of 48 optical fibres which are assembled into ribbons, each of which contains 6 fibres arranged in a flat edged bonded construction, typically by encapsulating the fibres in a UV cured acrylate material. 8 such ribbons each containing six fibres are installed inside a loose tube, typically extruded from a thermoplastic material, and the cable construction then completed by assembling tensile re-enforcement around the outside of the tube, and covering the assembly in a thermoplastic layer, in a manner similar to the arrangement shown in Figure 4. Such an arrangement is shown in cross-section in Figure 5.

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Central loose tube cables have the advantage of being more compact than traditional cables, and the fibre optic elements of such cables have considerable space in which to move. This provides the advantage of providing strain relief when the cables are bent.

Known cables, known as tight buffered fibre optic cables, represent another recent development in the trend towards miniaturisation. In such known cables, typically 12 optical fibres are installed inside a tube having an outside diameter of 1.2 mm, as shown in Figure 3, compared with 2mm for a conventional loose tube design, as shown in Figure 1 and 4,5 or 6 tight buffered 12 fibre tube units are arranged around a central strength member and then encapsulated in an outer polyethylene jacket. A cross-section of such a cable can also be represented by Figure 2.

EP 0521710 describes an even more compact arrangement in which the individual optical fibres, of which there are typically 2, 4 or 8; are touching each other and are encapsulated in an outer layer, typically a UV cured acrylate. The optical fibres are arranged in a very precise formation relative to each other, and the optical performance of the cable depends to a significant extent on the accurate location of the fibres relative to each other. This known cable suffers from the drawback that the higher the number of fibres within the assembly, the more difficult it is to achieve this precise location of the fibres.

EP 0422764 describes such an arrangement in which 12 fibres are provided, the fibres being accurately located and locked in position relative to each other by first assembling sets of 4 fibres into a ribbon sub-assembly by edge bonding the 4 fibres one to each other, and laying three such sub-assemblies on top of each other to form a basic construction which is then

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encapsulated in an outer layer comprising a UV cured acrylate. An example of such a cable assembly is shown in Figure 6.

However, known compact ribbon cable assemblies of this type suffer from the drawback that the surfaces of the ribbons in such cables are smooth, and the ribbons are therefore free to slide relative to each other. Also, because the fibres are bonded in a flat arrangement, when the cable is bent in a direction which imposes a sideways moment on the flat ribbons, the force generated is high and the central ribbon, which is free to slide between the two outer ribbons, is then forced to break out through the outer acrylate coating, producing micro bending and unacceptable signal losses.

Preferred embodiments of the present invention seek to overcome the above disadvantages of the prior art.

According to the present invention, there is provided a signal transmitting cable comprising a first signal transmitting portion including a plurality of elongate, flexible first signal transmitting members, wherein a plurality of said first signal transmitting members are arranged to form a plurality of rows, and wherein a plurality of said rows contain a plurality of said members arranged such that neighbouring members of a row are in touching contact with each other, and such that a plurality of recesses formed by neighbouring members of a first row accommodate respective members of a second row.

By providing a first signal transmitting portion in which neighbouring first signal transmitting members of a row are in touching contact with each other and in which a plurality of recesses formed by neighbouring members of a first row accommodate respective members of a second row, this provides the advantage of providing a much more compact construction than in the prior art, while effectively locking the individual

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fibres in place, thus avoiding the problem of fibre break out and providing a smaller overall diameter reducing the cost of raw material required to encapsulate the assembly.

The first signal transmitting portion may include at least 12 said members.

In a preferred embodiment, not all of said rows contain equal numbers of said signal transmitting members.

This provides the advantage that the fibres can be arranged with compact cross-sectional area and in an arrangement approximating to a circular construction, which provides a stable structure and minimises the extent to which the cable has a preferred bending direction. This in turn minimises twisting of the cable during installation thereof.

The first signal transmitting portion may further comprise a first layer in which said first signal transmitting members are arranged, such that at least the radially outermost of said first signal transmitting members are at least partially encapsulated by said first layer and hence prevented from moving axially relative to said first layer.

This provides the advantage that the first signal transmitting members can be embedded in the first layer, as opposed to constructions in which the fibres are encompassed in a tube of extruded thermoplastic material where the fibres are only in point contact with the encompassing material, so that voids can be filled and contact over a much wider area provided. This provides a much greater degree of friction between the outer first signal transmitting members and the first layer, which in turn provides the advantage of making it very difficult for one or more fibres to move relative to any of the others, which in

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turn minimises micro bending of the fibres and avoids unacceptable signal losses. -

A plurality of said first signal transmitting members may be capable of axial movement relative to said first layer.

In a preferred embodiment, only the radially outermost said first signal transmitting members are prevented from moving axially relative to said first layer.

This allows the manufacturing process to be completed in a single stage and hence provides the advantage of reducing the cost of manufacture of the cable.

The first layer may include plastics material cured by means of ultra violet radiation.

The cable may further comprise a second signal transmitting portion including a plurality of elongate, flexible second signal transmitting members arranged radially outwardly of said first signal transmitting portion, wherein each said second signal transmitting member is in touching contact with said first signal transmitting portion.

Adjacent said second signal transmitting members may be in touching contact with each other.

A plurality of said second signal transmitting members may be arranged in a plurality of groups.

This provides the advantage that each group of second signal transmitting members can be broken separately out of the cable making identification of the individual members much easier than in the case of the prior art, and enabling signal transmitting members of other groups to be left undisturbed,

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which is particularly useful where only some of signal transmitting members need to be terminated or connected at a certain point.

A plurality of said signal transmitting members may have substantially circular transverse cross section.

A plurality of said signal transmitting members may be optical fibres.

At least one said signal transmitting member may further comprise a respective protective coating surrounding said optical fibre.

An outer surface of the cable may be modified to increase the fluid drag of the cable.

Preferred embodiments of the invention will now be described by way of example only, and not in any limitative sense, with reference to the accompanying drawings, in which:-

Figure 1 is a cross-sectional view of a prior art loose tube sub-assembly forming part of a conventional reinforced cable;

Figure 2 is a cross-sectional view of a prior art cable incorporating several of the sub-assemblies of Figure 1;

Figure 3 is a cross-sectional view of a tight buffered sub assembly representing a more compact version of the cable sub-assembly of Figure 1;

Figure 4 is a cross-sectional view of a prior art central loose tube cable;

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Figure 5 is a cross-sectional view of a prior art central loose tube cable incorporating ribbons of edge bonded signal transmitting elements;

Figure 6 is a cross-sectional view of a compact prior art cable described in EP 0422764 in which signal transmitting elements are in edge to edge contact;

Figure 7 is a cross-sectional view of a fibre optical cable assembly of a first embodiment of the present invention;

Figure 8 is a cross-sectional view of a fibre optical cable assembly of a second embodiment of the present invention; and

Figure 9 is a schematic illustration of an arrangement for testing the performance of the cable of Figure 8.

Referring to Figure 7, a fibre optic cable 1 of a first embodiment of the present invention has a group of primary coated optical fibres 2 arranged in a coating 3 of UV-cured acrylate material. Such acrylate material 3 is available from DSM Desotech BV under the names DSM Cabelite 950-706 or DSM Cabelite 3287-9-41. The primary coated fibres 2 each consist of an optical fibre coated with a protective layer, as will be familiar to persons skilled in the art, and 12 coated fibres 2 are arranged in rows of touching fibres 2, adjacent rows being offset from each other, without the fibres 2 of each row being individually bonded to each other. This enables the fibres 2 to be nested together in a stable structure, and effective locks the individual fibres 2 in place relative to each other, avoiding the problems of the cable 1 having a preferential bending direction, and avoiding fibre breakout. Because the fibres 2 are nested, the assembly is more compact reducing the quantity of acrylate material 3 required, which is generally fairly-expensive, thus saving material.

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The fibres 2 are arranged in as "circular" an arrangement as possible to form the most stable possible structure and avoid the cable 1 having a preferential bending direction, and are embedded in the acrylate material 3 such that at least the outermost fibres 2 are prevented from moving axially relative to the cured acrylate material 3. The acrylate material fills any voids on the outermost surface of the structure formed by the fibres 2, which provides a greater degree of bonding between the outermost fibres 2 and the acrylate layer 2. This has the benefit of making it very difficult for one or more fibres 2 to move relative to any of the others, which in turn prevents microbending of the fibres and avoids unacceptable signal losses. The outer surface of the cable 1 is then modified, for example roughened, to facilitate blowing of the cable 1 into a duct by means of compressed air.

Referring to Figure 8, in which parts common to the embodiment of Figure 7 are denoted by like reference numerals but increased by 100, a fibre optic cable 101 of a second embodiment of the invention is a compact arrangement containing 48 optical fibres, and has 24 inner primary coated optical fibres 102 arranged in rows of touching fibres 102 to form a generally hexagonal arrangement, the inner fibres 102 being embedded in a layer of similar acrylate material 103 to the embodiment of Figure 7. The acrylate material 103 is then surrounded by 24 outer coated fibres 104, of identical construction to the fibres 102. The outer fibres 104 are arranged in a single layer of touching fibres 104, or can be arranged in groups of touching fibres 104 with spaces between the groups so that some, but not all, of the fibres may be broken out of the assembly for use without disturbing the other fibres of the assembly. The outer fibres 104 can be surrounded by further outer layers of fibres (not shown), and the addition

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of a further outer layer has a relatively small effect in increasing the diameter of the cable 101.

Referring now to Figure 9, the optical performance of a 1300 m length of the cable 1 of Figure 7 was tested by fusion splicing the individual fibres 2 together to create a single length of fibre 2 of length 12 times 1300 m. The optical power loss incurred as a result of repeated wrapping of the cable 1 around a 40mm diameter mandrel 150 was the measured at a wavelength of both 1550nm and 1310 nm over a measurement distance of 1000 m. The initial power loss was measured, the cable 1 was then wrapped around the mandrel 150 for 3 turns, and the power loss again measured. The cable 1 was then unwrapped and the power loss measured, the process repeated until 5 cycles has been completed, and the final power loss then measured. Using the initial power loss figures as a base value, the change in power loss was then calculated for each stage of the test.

The result of the test are set out in Table 1 below, and showed that the cable 1 comfortably met the requirement of a 4-fibre cable of smaller diameter that after recovery the power loss should not be greater than 0.05, although the cable of the present invention contains more fibres 2 and has a larger diameter.

Change of Power 1310nm (dB)												
Fibre no.	1	2	3	4	5	6	7	8	9	10	11	12
Fibre	YW	BN	BK	OR	GY	BL	WT	RD	AQ	PK	GN	VL
A Marker (km)	1.5	2.8	4.1	5.4	6.7	8.0	9.3	10.6	11.9	13.2	14.5	15.8
B Marker (km)	2.5	3.8	5.1	6.4	7.7	9.0	10.3	11.6	12.9	14.2	15.5	16.8
Before	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Flex 1	-	0.007	-	-	0.000	0.006	-	-	0.002	0.003	0.002	-
	0.001		0.008	0.004			0.001	0.004				0.003
Recover 1	0.001	0.007	-	-	0.005	0.003	-	-	-	0.006	0.003	-
			0.007	0.004			0.003	0.004	0.001			0.004
Flex 2	0.003	0.002	0.014	0.002	0.009	0.014	0.001	0.004	0.004	0.007	0.005	0.001
Recover 2	0.006	-	0.003	0.000	0.016	0.013	-	-	0.002	0.002	0.001	-
		0.001					0.003	0.005				0.004
Flex 3	0.008	0.002	0.057	0.006	0.020	0.021	0.000	0.017	0.011	0.023	0.004	0.004

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Recover 3	0.008	0.000	- 0.004	0.002	0.015	0.012	- 0.005	- 0.005	0.006	0.005	0.005	- 0.002
Flex 4	0.006	0.002	0.041	0.007	0.018	0.017	0.002	0.015	0.013	0.021	0.001	0.002
Recover 4	0.005	0.003	- 0.010	0.012	0.015	0.012	- 0.005	0.000	- 0.001	0.002	0.001	- 0.004
Flex 5	0.005	0.002	0.042	0.008	0.019	0.018	- 0.001	0.010	0.002	0.024	- 0.001	0.001
After	0.002	0.002	- 0.008	0.006	0.016	0.011	- 0.005	- 0.002	- 0.003	0.001	- 0.001	- 0.005

Change of Power 1550nm (dB)												
Fibre no.	1	2	3	4	5	6	7	8	9	10	11	12
Fibre	YW	BN	BK	OR	GY	BL	WT	RD	AQ	PK	GN	VL
A Marker (km)	1.5	2.8	4.1	5.4	6.7	8.0	9.3	10.6	11.9	13.2	14.5	15.8
B Marker (km)	2.5	3.8	5.1	6.4	7.7	9.0	10.3	11.6	12.9	14.2	15.5	16.8
Before	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Flex 1	0.003	0.007	0.017	0.023	0.002	0.003	0.069	0.008	0.100	0.012	0.014	0.021
Recover 1	- 0.002	0.003	- 0.004	- 0.002	- 0.006	- 0.001	- 0.002	0.000	0.002	0.000	0.005	- 0.003
Flex 2	0.050	0.064	0.405	0.137	0.058	0.109	0.130	0.224	0.116	0.225	0.051	0.166
Recover 2	0.002	- 0.001	- 0.001	- 0.005	- 0.015	0.002	0.003	- 0.001	0.001	0.004	0.008	- 0.002
Flex 3	0.100	0.115	0.848	0.251	0.131	0.215	0.318	0.406	0.200	0.441	0.100	0.265
Recover 3	0.000	0.002	- 0.002	- 0.010	- 0.014	- 0.003	0.008	- 0.005	0.002	0.002	0.008	- 0.006
Flex 4	0.099	0.116	0.776	0.224	0.118	0.185	0.316	0.399	0.175	0.387	0.093	0.285
Recover 4	0.002	0.001	- 0.002	- 0.004	- 0.013	- 0.004	0.013	- 0.002	0.002	0.004	0.004	- 0.002
Flex 5	0.080	0.089	0.743	0.177	0.108	0.160	0.253	0.388	0.145	0.376	0.076	0.257
After	0.003	0.001	- 0.006	- 0.001	- 0.012	- 0.007	0.013	- 0.002	0.003	0.004	0.002	- 0.006

In addition to the surprisingly good blowing properties of the cable of the present invention, it is also found that by first nesting the fibres 2, 102 and then embedding the fibres 2, 102 in a layer of UV-curable acrylate material 3, 103, this has the surprising effect of providing an extremely stable structure with excellent bending characteristics without the necessity to coat each individual fibre, as is the case with edge bonded ribbons. This enables the cable 1 or inner part of cable 101 to be assembled in a single process and makes it possible to reduce the quantity of expensive UV curable acrylate material used.

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It will be appreciated by persons skilled in the art that the above embodiments have been described by way of example only and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope of the invention as defined by the appended claims. In particular it will be appreciated that an assembly such as that shown in Figure 7 could be used as a sub assembly for larger cables such as that shown in Figure 2.

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## CLAIMS

1. A signal transmitting cable comprising a first signal transmitting portion including a plurality of elongate, flexible first signal transmitting members, wherein a plurality of said first signal transmitting members are arranged to form a plurality of rows, and wherein a plurality of said rows contain a plurality of said members arranged such that neighbouring members of a row are in touching contact with each other, and such that a plurality of recesses formed by neighbouring members of a first row accommodate respective members of a second row.
2. A cable according to claim 1, wherein the first signal transmitting portion includes at least 12 said members.
3. A cable according to claim 1 or 2, wherein not all of said rows contain equal numbers of said signal transmitting members.
4. A cable according to any one of the preceding claims, wherein the first signal transmitting portion further comprises a first layer in which said first signal transmitting members are arranged, such that at least the radially outermost of said first signal transmitting members are at least partially encapsulated by said first layer and hence prevented from moving axially relative to said first layer.
5. A cable according to claim 4, wherein a plurality of said first signal transmitting members are capable of axial movement relative to said first layer.
6. A cable according to claim 4 or 5, wherein only the radially outermost said first signal transmitting members are prevented from moving axially relative to said first layer.

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7. A cable according to any one of the preceding claims, wherein the first layer includes plastics material cured by means of ultra violet radiation.

8. A cable according to any one of the preceding claims, further comprising a second signal transmitting portion including a plurality of elongate, flexible second signal transmitting members arranged radially outwardly of said first signal transmitting portion, wherein each said second signal transmitting member is in touching contact with said first signal transmitting portion.

9. A cable according to claim 8, wherein adjacent said second signal transmitting members are in touching contact with each other.

10. A cable according to claim 8 or 9, wherein a plurality of said second signal transmitting members are arranged in a plurality of groups.

11. A cable according to any one of the preceding claims, wherein a plurality of said signal transmitting members have substantially circular transverse cross section.

12. A cable according to any one of the preceding claims, wherein a plurality of said signal transmitting members are optical fibres.

13. A cable according to claim 12, wherein at least one said signal transmitting member further comprises a respective protective coating surrounding said optical fibre.

14. A cable according to any one of the preceding claims, wherein an outer surface of the cable is modified to increase the fluid drag of the cable.

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15. A signal transmitting cable substantially as hereinbefore described with reference to Figures 7 to 9 of the accompanying drawings.

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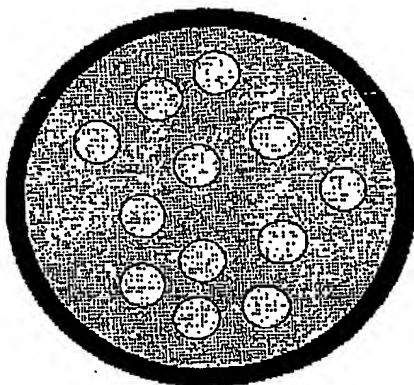


Fig 1  
Prior Art

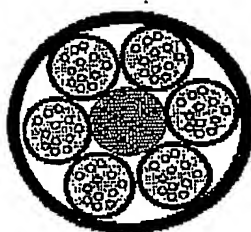


Fig 2  
Prior Art

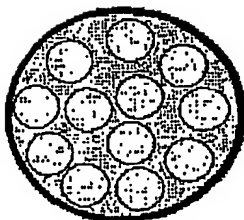


Fig 3  
Prior Art

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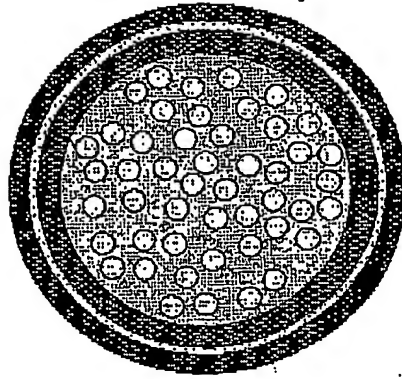


Fig 4  
Prior Art

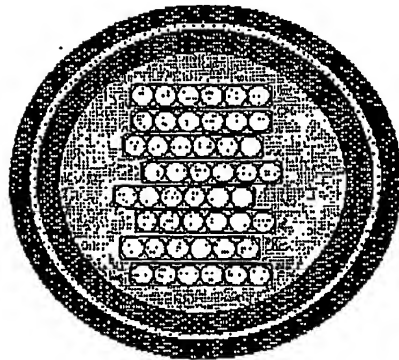


Fig 5  
Prior Art

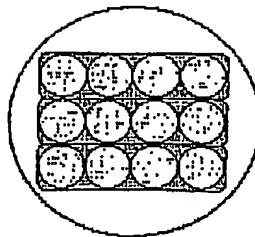


Fig 6  
Prior Art

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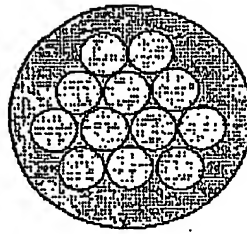


Fig 7.

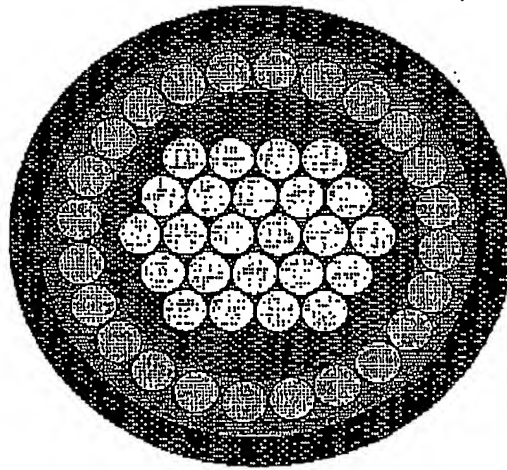


Fig 8

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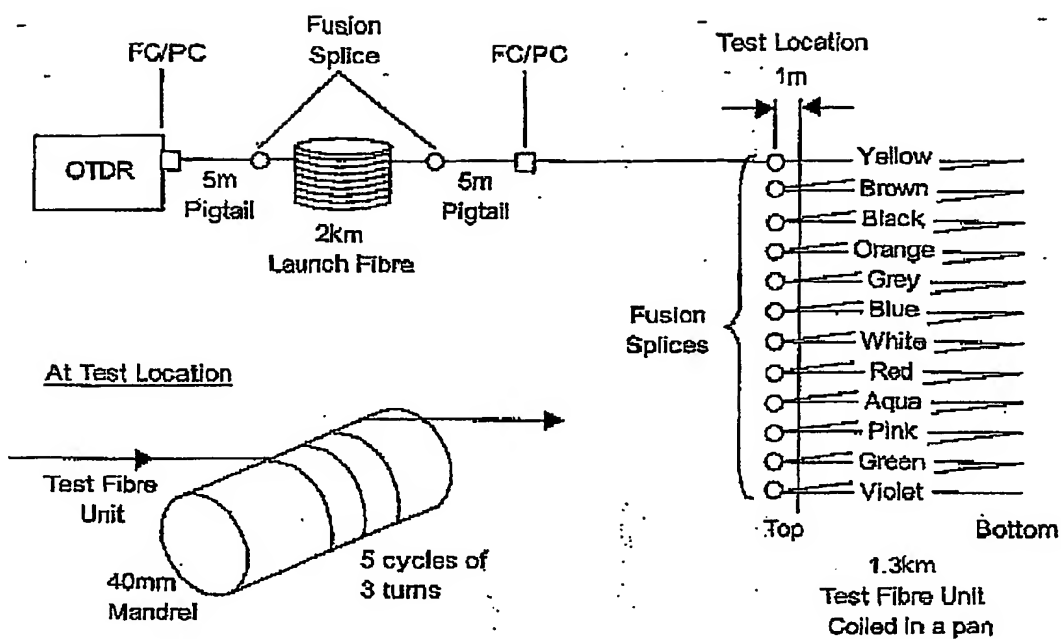


Fig 9